MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question. Circle the Correct Answer.

1) A professor runs a regression to see how students' exam scores (Y) are related to their homework grades (X). The $R^2$ of the regression is 21%. What does $R^2$ tell us?
   A) 21% of each student's exam grade will be determined by their homework grade.
   B) 21% of students have their grades accurately predicted by the regression equation.
   C) none of these
   D) Exam scores are not related to homework grades since 21% is greater than 5%.
   E) 21% of the variation in the exam scores is explained by the regression analysis.

2) The Y-variable in a regression analysis is also known as the...
   A) response variable
   B) independent variable
   C) explanatory variable
   D) none of these
   E) predictor variable

3) A university administrator obtains a sample of the academic records of past and present scholarship athletes at the university. The administrator reports that no significant difference was found in the mean GPA (grade point average) for male and female scholarship athletes ($p=0.287$). This means:
   A) the chance of obtaining a difference in GPAs between male and female scholarship athletes as large as that observed in the sample if there is no difference in GPAs is 0.287.
   B) the maximum difference in GPAs between male and female scholarship athletes is 0.287.
   C) the GPAs for male and female scholarship athletes are identical, except for 28.7% of the athletes.
   D) the chance that a pair of randomly chosen male and female scholarship athletes would have a significant difference in GPAs is 0.287.

4) We want to know the mean winning score at the US Open golf championship. An internet search gives us all the scores for the history of that tournament, and we create a 95% confidence interval based on a $t$-distribution. This procedure was not appropriate. Why?
   A) Since these are the best players in the world, the scores are probably skewed.
   B) In big golf tournaments the players are not randomly selected.
   C) The population standard deviation is known, so we should have used a $z$-model.
   D) The recent record-setting score is probably an outlier.
   E) The entire population of scores was gathered so there is no reason to do inference.
5) The scores of a certain population on the Wechsler Intelligence Scale for Children (WISC) are thought to be normally distributed, with mean \( \mu \) and standard deviation \( \sigma = 10 \). I wish to test whether the mean from my sample of that population differs from the national average of 100, so I use the hypotheses \( H_0: \mu = 100 \) and \( H_a: \mu \neq 100 \), based on a simple random sample of size 25 from the population. I calculate a 95% confidence interval for \( \mu \) and find it to be 100.76 to 106.24. Which of the following is true?

A) I would reject \( H_0 \) at level .05  
B) I would reject \( H_a \) at level .05  
C) The p-value is .05  
D) A mistake has been made because the confidence interval must certainly contain \( \mu \) at least 95 of the time.

6) Which of the following statements is NOT an assumption of inference for a regression model?

A) The errors around the idealized regression line have equal variability.  
B) The errors around the idealized regression line are linearly related.  
C) The dependent variable is linearly related to the explanatory variables.  
D) The errors around the idealized regression line are independent of each other.  
E) The errors around the idealized regression line follow a Normal model.

7) The problem of collinearity occurs when

A) at least one predictor var. has a nonlinear relationship with the response variable.  
B) there is an influential observation in the data set.  
C) more than one predictor variable is linearly related to the response variable.  
D) none of these  
E) two or more predictor variables are linearly related to each other.

8) ANOVA

A) is the abbreviation for analysis of variance.  
B) helps control EREW (error rate experiment wise) by computing an overall test for group differences before conducting multiple pairwise comparisons.  
C) has an F ratio as the test statistic.  
D) is described by all of the above.

9) Which of the following are NOT characteristics of a good regression model?

A) a relatively low value of \( s \) (the standard deviation of the residuals)  
B) relatively small p-values for the F- and t-statistics  
C) a relatively high \( R^2 \)  
D) relatively few predictor variables  
E) All of these are characteristics of a good regression model.

10) A new superintendent at Harper Valley public school district is interested in comparing the attendance for the various grades in his elementary, middle and high schools. They are planning on calculating the mean days attended for grades 1-12 and then doing pairwise t-tests to compare each grade with every other grade. What might you say to them?

A) your EREW is expanding with each comparison.  
B) your error rate per comparison is equal to alpha.  
C) multiple comparisons will lead to a rejection of the null 2 or 3 times just by chance alone.  
D) all of the above.
### SHORT ANSWER

11) **Gas mileage** Hoping to improve the gas mileage of their cars, a car company has made an adjustment in the manufacturing process. Random samples of automobiles coming off the assembly line have been measured each week that the plant has been in operation. The data from before (M1) and after (M2) the manufacturing adjustments were made are compared below. It is believed that measurements of gas mileage are normally distributed. Write a complete conclusion about the manufacturing adjustments based on the output from R shown below.

```r
## data: GASMILEAGE by ADJUSTMENT
## t = 2.88, df = 24.98, p-value = 0.0041
## alternative hypothesis: Gas mileage after adjustment is less than before adjustment

## 95% percent confidence interval:
## 0.74   4.45

## sample estimates:
## mean before adjustment mean after adjustment
## 22.71   25.32
```
12) **Class matters.** Among the 2201 souls on the Titanic, most died on the night it sank. We wish to know if survival was related to class (e.g., first class, second class, steerage [3rd class] or a crew member). All the conditions are satisfied - don't worry about checking them.

Survival

<table>
<thead>
<tr>
<th>class</th>
<th>Alive</th>
<th>Dead</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1stclass</td>
<td>203</td>
<td>122</td>
<td>325</td>
</tr>
<tr>
<td>2ndclass</td>
<td>118</td>
<td>167</td>
<td>285</td>
</tr>
<tr>
<td>3rdclass</td>
<td>178</td>
<td>528</td>
<td>706</td>
</tr>
<tr>
<td>crew</td>
<td>212</td>
<td>673</td>
<td>885</td>
</tr>
<tr>
<td>Total</td>
<td>711</td>
<td>1490</td>
<td>2201</td>
</tr>
</tbody>
</table>

Pearson's Chi-squared test

X-squared = 190.4, df = 3, p-value < 2.2e-16

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>203</td>
<td>122</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(104.99)</td>
<td>(220.01)</td>
<td>key:</td>
</tr>
<tr>
<td></td>
<td>[91.50]</td>
<td>[43.66]</td>
<td>observed</td>
</tr>
<tr>
<td></td>
<td>&lt; 9.57&gt;</td>
<td>&lt;-6.61&gt;</td>
<td>(expected)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>[contribution to X-squared]</td>
</tr>
<tr>
<td>118</td>
<td>167</td>
<td></td>
<td>&lt;Pearson residual&gt;</td>
</tr>
<tr>
<td></td>
<td>(92.06)</td>
<td>(192.94)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[7.31]</td>
<td>[3.49]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;2.70&gt;</td>
<td>&lt;-1.87&gt;</td>
<td></td>
</tr>
<tr>
<td>178</td>
<td>528</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(228.06)</td>
<td>(477.94)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[10.99]</td>
<td>[5.24]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;-3.32&gt;</td>
<td>&lt;2.29&gt;</td>
<td></td>
</tr>
<tr>
<td>212</td>
<td>673</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(285.89)</td>
<td>(599.11)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[19.10]</td>
<td>[9.11]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;-4.37&gt;</td>
<td>&lt;3.02&gt;</td>
<td></td>
</tr>
</tbody>
</table>

a. Write appropriate hypotheses.

b. How many degrees of freedom?

c. State your complete conclusion in context.
13) Homelessness is a problem in many large U.S. cities. To better understand the problem, a multiple regression was used to model the rate of homelessness based on several explanatory variables. The following data were collected for 50 large U.S. cities. The regression results appear below.

- **Homeless**: number of homeless people per 10,000 in a city
- **Poverty**: percent of residents with income under the poverty line
- **Unemployment**: percent of residents unemployed
- **Temperature**: average yearly temperature (in degrees F.)
- **Vacancy**: percent of housing that is unoccupied
- **Rent Control**: indicator variable, 1 = city has rent control, 0 = no rent control

The variable (Y) is Homelessness

| Coefficients: | Estimate | Std. Error | t value | Pr(>|t|) |
|---------------|----------|------------|---------|----------|
| (Intercept)   | -4.275   | 3.465      | -1.23   | 0.2239   |
| Poverty       | 0.08239  | 0.0823     | 1.00    | 0.3228   |
| Unemployment  | 0.159    | 0.218      | 0.73    | 0.4699   |
| Temperature   | 0.135    | 0.0587     | 2.30    | 0.0262   |
| Vacancy       | -0.247   | 0.138      | -1.79   | 0.0809   |
| RentControl   | 2.944    | 1.37       | 2.15    | 0.0373   |

- 32 degrees of freedom
- Multiple R-squared: 0.384, Adjusted R-squared: 0.315

a. Using a 5% level of significance, which variables are associated with the number of homeless in a city?

b. Explain the meaning of the coefficient of temperature in the context of this problem.

c. Explain the meaning of the coefficient of rent control in the context of this problem.

d. Do the results suggest that having rent control laws in a city causes higher levels of homelessness? Explain.

e. If we created a new model by adding several more explanatory variables, which statistic should be used to compare them - the $R^2$ or the adjusted $R^2$? Explain.

f. Using the plots below, check the regression conditions.
To discourage cheating, a professor makes three different versions of an exam. For the 105 students in her class, she makes 35 copies of each version. The 105 exams are randomly scrambled, and one copy is given to each student. After the exam, the professor is concerned that one version might have been easier than the others. She uses a one-way ANOVA to test whether the average score was different for the three versions. The ANOVA table and a boxplot of the results are below.

<table>
<thead>
<tr>
<th></th>
<th>Df</th>
<th>Sum Sq</th>
<th>Mean Sq</th>
<th>F value</th>
<th>Pr(&gt;F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Version</td>
<td>2</td>
<td>771.943</td>
<td>385.971</td>
<td>4.4317</td>
<td>0.0143</td>
</tr>
<tr>
<td>Residuals</td>
<td>102</td>
<td>8883.49</td>
<td>87.093</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. What hypotheses are tested by this ANOVA? State null and alternative in statistical terms and in context.

b. Write a sentence describing the conclusion of the test in the context of this problem.
15) A city council must decide whether to fund a new “welfare-to-work” program to assist long-time unemployed people in finding jobs. This program would help clients fill out job applications and give them advice about dealing with job interviews. A six-month trial has just ended. At the start of this trial a number of unemployed residents were randomly divided into two groups; one group went through the Help program and the other group did not. Of the 54 residents who were in the Help program 20 found employment compared to 13 of the 46 who did not participate in the Help program.

a. State appropriate hypotheses.

b. Find a 95% confidence interval for the difference in the proportions of employment among those in the program and not in the program.

c. Interpret your interval.

d. State your conclusions.

e. Should the city council fund this program?
PICKING THE RIGHT STATISTIC – For each of the following studies described, indicate which inferential test is most appropriate. Do not conduct the test!

Possible Answers for Questions 16-18 are:

A. One sample z test for a proportion
B. Two sample z test for proportions or CI for difference
C. One sample t-test for a mean
D. Two sample t-test for means – independent groups
E. Two sample t-test for means – paired groups
F. Correlation/Linear Regression
G. Chi square
H. ANOVA

____16. Has a new math program instituted in the high school in 2003 helped improve math SAT scores? A random sample of four students was selected to take the SAT in 2003 before the new math program was instituted. Three years later another random sample of four students was selected to take the SAT. The scores of both sets of students are given below.

<table>
<thead>
<tr>
<th>Group</th>
<th>SAT scores 2003</th>
<th>SAT scores 2006</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>420 530 720 610</td>
<td>610 730 620 430</td>
</tr>
</tbody>
</table>

____17. Recent revenue shortfalls in a Southern state led to a reduction in the state budget for higher education. To offset the reduction, the largest state university proposed a 25% tuition increase. It was determined that such an increase was needed to simply compensate for the lost support from the state. Random samples of 50 first years, 50 sophomores, 50 juniors, and 50 seniors from the university were asked whether they were strongly opposed to the increase, given that it was the minimum increase necessary to maintain the university’s budget at current levels. The results are given in the following table. Which test is most appropriate to evaluate if there is a relationship between year and opposition?

<table>
<thead>
<tr>
<th>Year</th>
<th>Freshman</th>
<th>Sophomore</th>
<th>Junior</th>
<th>Senior</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>39</td>
<td>36</td>
<td>29</td>
<td>18</td>
</tr>
<tr>
<td>No</td>
<td>11</td>
<td>14</td>
<td>21</td>
<td>32</td>
</tr>
</tbody>
</table>

____18. Some students in an introductory statistics class at Amherst College were using data from the General Social Survey (GSS) and saw that approximately 88% of the sample reported their race as white. Being the thorough students that they were, they went to the U.S. Census Bureau website to get information from the most recent census and discovered that only 79.8% of the U.S. population is white. What test can use to evaluate whether the GSS oversampled whites.
Possible Answers for Questions 19-21 are:

A. One sample z-test for a proportion
B. Two sample z-test for proportions or CI for difference
C. One sample t-test for a mean
D. Two sample t-test for means – independent groups
E. Two sample t-test for means – paired groups
F. Correlation/Linear Regression
G. Chi square
H. ANOVA

_______19. In 2000, the United Nations claimed that there was a higher rate of illiteracy in men than in women from the country of Qatar. A humanitarian organization went to Qatar to conduct a random sample. The results revealed that 45 out of 234 men and 42 out of 251 women were classified as illiterate on the same measurement test. How can you evaluate if the literacy rates are different?

_______ 20. An engineer working for a leading electronic firm claims to have invented a process for making longer-lasting TVs. Tests run on 24 TVs made with the new process show a mean life of 1,725 hours and a standard deviation of 85 hours. Tests run over the last 3 years on a very large number of TVs made with old process show a mean life of 1,538 hours. How can we evaluate the engineer’s claim?

_______ 21. The dean of admissions at large university wonders how strong the relationship is between high school grades and college grades. During the two years that he has held this position, he has weighted high school grades heavily when deciding which students to admit to the university, yet has never seen any data relating the two variables. Having a strong experimental background, he decides to conduct a study and find out for himself. He randomly samples 15 seniors from his university and obtains their high school and college grades to find out if high school grades are indicative of college performance.

HAVE A GREAT BREAK!

NOTE: EXTRA CREDIT ON NEXT PAGE
EXTRA CREDIT:
You find the following R output on a printout in the computer lab. What do you make of it?

```r
> mu=69.3
> menonlyds <- filter(bball, GENDER=="Male")
> t.test(HEIGHTIN, alternative="greater", mu=69.3, data=menonlyds)

One Sample t-test

data:  HEIGHTIN
t = 10.743, df = 11, p-value = 0.0000001798
alternative hypothesis: true mean is greater than 69.3
95 percent confidence interval:
  78.14188      Inf
sample estimates:
mean of x
  79.91667
```